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INVESTIGATION OF THE QUADRUPOLE DEFORMATION
OF ¹¹B BY MEANS OF 30 MeV POLARIZED PROTON
INELASTIC SCATTERING

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Résumé. — Les sections efficaces et pouvoirs d'analyse de la diffusion inélastique ¹¹B(p, p') à $E_p = 30,3$ MeV ont été analysés dans le formalisme des équations couplées. Ces calculs suggèrent la valeur positive de la déformation quadrupolaire β_2 du ¹¹B (prolate) et donnent le résultat suivant $\beta_2 = + 0,52$.

Abstract. — The cross-sections and resolving powers of the ¹¹B(p, p') inelastic scattering at $E_p = 30.3$ MeV are analyzed in the coupled-channels formalism. These calculations suggest a positive value for the quadrupole deformation β_2 of ¹¹B (prolate) and give the result $\beta_2 = + 0.52$.

In the understanding of 1p shell nuclei, the investigation of their deformation plays an important role. For the ¹¹B nucleus, Hartree-Fock calculations [1] do not give a prolate lower minimum compatible with the positive electric quadrupole moment obtained from experiments. For this nucleus a strong-coupling rotational model [2] has given a better result although a quantitative disagreement with the experimentally determined electric quadrupole moment still remains [3].

The above discrepancies have suggested that we need much more investigations about the quadruple deformation of the ¹¹B nucleus by means of inelastic scattering. In particular a recent investigation of the quadrupole deformation of ¹¹B by inelastic helium (³He) scattering at $E_{^3\text{He}} = 74$ MeV [4] has shown, with analysis using the coupled-channels (CC) method, the possible existence of oblate-prolate effects of ¹¹B in this reaction. It would therefore appear necessary to determine the quadrupole deformation of ¹¹B by means of polarized proton inelastic scattering.

In view of the determination of the sign and the value for the quadrupole deformation β_2 of ¹¹B, we have analyzed, in the coupled-channels (CC) formalism with the rotational model using the code ECIS 75 [5], the experimental data for the cross-sections and resolving powers in the ¹¹B(p, p) and ¹¹B(p, p') scattering to the lower two members of the $K^\pi = \frac{3}{2}^-$ band of ¹¹B, i.e. the $\frac{3}{2}^-$ ground state and the $\frac{5}{2}^-$ second-excited state ($E_x = 4.46$ MeV) at $E_p = 30.3$ MeV [6]. The optical parameters used as initial values for the optical model search procedure were taken from the analysis performed by Karban *et al.* [6] and are listed in table I. In the CC formalism, the nuclear radius is defined by

$$R = R_i(1 + \beta_2 Y_{20} + \cdots)$$

where the β 's are the deformation parameters determined by the experiment, the Y 's are spherical harmonics and R_i corresponds to the various optical potential radii. The interaction potential arises from the deformation of the Coulomb potential, the complex central potential and the spin-orbit potential. The deformed spin-orbit potential was of the full Thomas form [7]. In the CC calculations, the states explicitly coupled are the lower two members of a

TABLE I
Optical model parameters used in the analysis of the ¹¹B(p, p)¹¹B scattering

V_0 (MeV)	r_0 (fm)	a_0 (fm)	W_v (MeV)	W_D (MeV)	r_1 (fm)	a_1 (fm)	V_{s0} (MeV)	r_{s0} (fm)	a_{s0} (fm)	r_C (fm)
45.18	1.09	0.59	0	3.38	1.30	1.01	7.78	0.98	0.57	1.09

$K = \frac{3}{2}^-$ rotational band in ^{11}B . The results are presented in figure 1 and the corresponding parameters listed in table II.

The two values $\beta_2 = +0.43$ and $\beta_2 = -0.50$ obtained from reference [4] by analyzing only the cross-sections of the $^{11}\text{B}(^3\text{He}, ^3\text{He}')$ inelastic scattering at $E_{^3\text{He}} = 74$ MeV with the CC method give equally low χ^2 values. But it should be mentioned [4] that $\beta_2 = +0.43$ agrees quite well with the experimental value of $+0.0372$ b [3] for the electric quadrupole moment. The results we have obtained by analyzing simultaneously the cross-sections and resolving powers of the $^{11}\text{B}(\text{p}, \text{p}')^{11}\text{B}^*$ inelastic scattering at $E_p = 30.3$ MeV using the CC calculations suggest also a positive value for the quadrupole deformation β_2 of ^{11}B (prolate) and give the result $\beta_2 = +0.52$.

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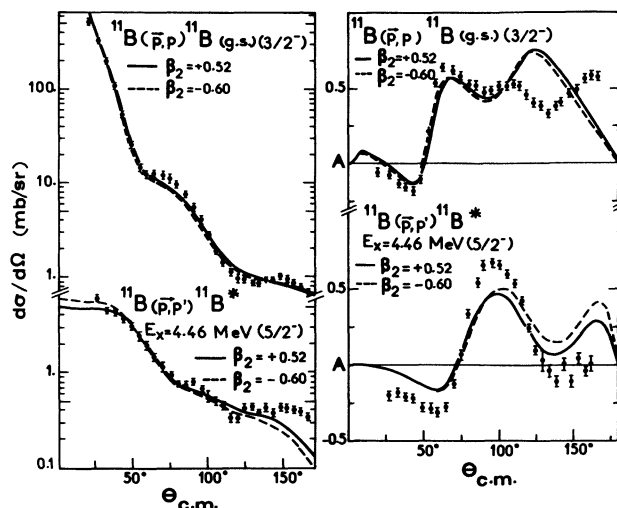


FIG. 1. — Experimental results of the $^{11}\text{B}(\text{p}, \text{p}')^{11}\text{B}^*$ scattering compared to the results of the coupled-channels calculations corresponding to the two parameter sets of table II.

TABLE II

Coupled-channel parameters used in the analysis of the $^{11}\text{B}(\text{p}, \text{p}')^{11}\text{B}^$ inelastic scattering*

β_2	V_0 (MeV)	r_0 (fm)	a_0 (fm)	W_v (MeV)	W_D (MeV)	r_1 (fm)	a_1 (fm)	V_{s0} (MeV)	r_{s0} (fm)	a_{s0} (fm)	r_c (fm)	χ^2
—	—	—	—	—	—	—	—	—	—	—	—	—
+ 0.52	46.65	1.09	0.59	0	3.22	1.30	1.01	8.38	0.98	0.57	1.09	34.83×10^2
- 0.60	46.98	1.09	0.59	0	3.34	1.30	1.01	8.34	0.98	0.57	1.09	38.48×10^2

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